

CLAIMS

What is claimed is:

1           1.    A method of detecting leaks in an  
2   extracorporeal blood circuit, comprising the steps of:  
3           detecting fluid outside a first portion of a  
4   blood circuit;  
5           detecting air inside a second portion of a blood  
6   circuit located remote from said first portion such that  
7   fluid is not detectable from said second portion;

8           generating an alarm signal responsively to a  
9   result of either or both of said steps of detecting.

1           2.    A method as in claim 1, wherein said first  
2   step of detecting includes providing a fluid sensor below  
3   said circuit first portion and sensing a presence of blood  
4   with said sensor.

1           3.    A method as in claim 1, wherein said second  
2   step of detecting includes applying a positive gauge  
3   pressure to said circuit during a first time and applying a  
4   negative pressure to said blood circuit during a second  
5   time.

1           4.    A method as in claim 1, wherein said step of  
2   generating includes generating an alarm if either of said

3 first and second steps of detecting results in an  
4 indication of a leak.

1 5. A method as in claim 1, wherein said second  
2 step of detecting includes periodically reversing a flow in  
3 said blood circuit.

1 6. A method as in claim 1, wherein said second  
2 step of detecting includes positioning a funnel with a  
3 fluid detector under a blood processing machine.

1 7. A method as in claim 1, wherein said second  
2 portion includes tubing linking a patient to a blood  
3 processing machine.

1 8. A method as in claim 7, wherein said first  
2 portion includes a portion of said blood circuit at least  
3 partially housed by a blood processing machine.

1 9. A method as in claim 8, wherein said step of  
2 detecting fluid includes directing a flow of fluid by  
3 gravity by means of a funnel to a fluid detector.

1 10. A leak detection system for an  
2 extracorporeal blood circuit, comprising:

3 a fluid detector located in a position to capture  
4 leaking blood from a first portion of said blood circuit;

5 a mechanism in said blood circuit to, at least  
6 periodically, create a negative pressure in all portions of

7 a patient side of said blood circuit such that any leaks in  
8 said all portions will result in infiltration of air;

9 an air infiltration detector located to detect  
10 air infiltrating said second portion;

11 an alarm connected to both said air infiltration  
12 detector and said fluid detector and configured to generate  
13 an alarm signal if either said air infiltration detector or  
14 said fluid detector indicates a leak.

1 11. A device as in claim 10, further comprising  
2 a container positioned with respect to said fluid detector  
3 to guide blood leaking from said blood circuit toward said  
4 fluid detector.

1 12. A device as in claim 10, wherein said  
2 mechanism includes a device adapted to reverse flow in said  
3 blood circuit.

1 13. A device as in claim 12, wherein said device  
2 adapted to reverse flow includes a reversing valve.

1 14. A device as in claim 13, further comprising  
2 a funnel-shaped container positioned with respect to said  
3 fluid detector to guide blood leaking from said blood  
4 circuit toward said fluid detector located at a bottom of  
5 said container.

1           15. A device as in claim 14, wherein said  
2 funnel-shaped container is built into a housing of a blood  
3 processing machine of which said blood circuit is a part.

1           16. A device as in claim 10, wherein said air  
2 infiltration detector is a detector of the presence of air  
3 in said blood circuit.

1           17. A device for detecting leaks in a blood  
2 circuit, comprising:

3           a first leak detector that detects leaks by  
4 sensing blood outside said blood circuit, said first leak  
5 detector being located to detect leaks from a first portion  
6 of said blood circuit located remote from a patient;

7           a second leak detector that detects leaks by  
8 sensing air infiltration into lines under negative  
9 pressure;

10           said second leak detector being configured to  
11 detect leaks in lines connecting said patient to said first  
12 portion;

13           a mechanism that insures that at least part of  
14 said lines are under negative pressure at least part of the  
15 time during a treatment such that a detectable air  
16 infiltration indicates a presence of a leak in said lines;

17 an alarm device that outputs an alarm signal  
18 responsively to a detection of a leak by said first or  
19 second leak detector.

1 18. A device as in claim 17, wherein said second  
2 leak detector includes a fluid sensor below said circuit  
3 first portion.

1 19. A device as in claim 17, wherein said  
2 mechanism includes a flow-reversing valve in said blood  
3 circuit effective to reverse flow in said lines.

1 20. A device as in claim 17, where in said first  
2 leak detector is located below said first portion, said  
3 device further comprising a flow director to concentrate  
4 leaking fluid toward said first leak detector.

1 21. A method of detecting a fluid leak from a  
2 fluid processing machine, comprising the steps of:

3 detecting infiltration of air into a fluid  
4 circuit;

5 detecting leakage of fluid from said fluid  
6 circuit;

7 generating an alarm responsively to said first  
8 and second steps of detecting.

22. A method as in claim 21, wherein said step of generating includes generating an alarm when either of said steps of detecting indicates a leak.

23. A method as in claim 21, wherein said first step of detecting is restricted to detecting infiltration into a first part of said fluid circuit and said second step of detecting is restricted to detecting fluid leaking from a second part of said fluid circuit, said first and second parts having separate respective portions.

24. A method as in claim 21, wherein said first step of detecting includes generating a negative pressure in said fluid circuit.

25. A method as in claim 25, wherein said step of generating includes reversing a flow of fluid.

26. A method as in claim 21, wherein said fluid is blood.

27. A method as in claim 21, wherein said fluid processing machine is an extracorporeal blood processing machine.

28. A method of detecting a leak from a blood circuit of an extracorporeal blood treatment machine, comprising the steps of:

31 detecting leakage of blood from respective  
32 portions of a blood circuit;

33 said step of detecting including detecting  
34 different physical effects resulting from respective  
35 conditions associated with one or more leaks;

36 said respective portions including parts that are  
37 non-overlapping.

38 29. A method as in claim 28, wherein said step  
39 of detecting includes triggering an indicator of a leak  
40 responsively to a result of either of said respective  
41 different physical effects.

42 30. A method as in claim 29, further comprising  
43 at least one of clamping a fluid line, stopping a pump, or  
44 actuating a flow controller responsively to said indicator.

45 31. A method as in claim 29, further comprising  
46 triggering an alarm responsively to said indicator.

47 32. A method as in claim 28, wherein said  
48 different physical effects include the infiltration of air  
49 into a blood circuit and the presence of blood outside said  
50 blood circuit.

51 33. A method as in claim 32, further comprising  
52 controlling an output device responsively to said  
53 indicator.

54           34. A method as in claim 32, further comprising  
55 at least one of clamping a fluid line, stopping a pump, or  
56 actuating a flow controller responsively to said indicator.

57           35. A method as in claim 32, further comprising  
58 outputting an alarm signal responsively to said indicator.

59           36. A method as in claim 35, wherein said step  
60 of detecting includes triggering an indicator of a leak  
61 responsively to a result of either of said respective  
62 different physical effects.

63           37. A method as in claim 36, wherein said  
64 different physical effects include the infiltration of air  
65 into a blood circuit and the presence of blood outside said  
66 blood circuit.

67           38. A method as in claim 28, wherein said  
68 different physical effects include the infiltration of air  
69 into a blood circuit by periodically generating a negative  
70 pressure in said blood circuit and the presence of blood  
71 outside said blood circuit.

72           39. A method as in claim 38, wherein said step  
73 of generating includes reversing a flow of blood.

74           40. A method as in claim 28, wherein said  
75 different physical effects include the infiltration of air  
76 into a blood circuit by periodically reversing a flow of



77 blood in said blood circuit using a reversing valve and the  
78 presence of blood outside said blood circuit.

79 41. A method as in claim 40, wherein said  
80 presence is detected using a sensor located inside a  
81 housing of said extracorporeal blood treatment machine.

82 42. A method as in claim 40, wherein said  
83 presence is detected by guiding and concentrating a leaking  
84 flow of blood toward a fluid sensor.

85 43. A device for detecting a fluid leak from a  
86 fluid processing machine, comprising the steps of:

87 an air detection sensor located to detect  
88 infiltration of air into a fluid circuit of said fluid  
89 processing machine;

90 a fluid detector located to detect a leakage of  
91 fluid from said fluid circuit;

92 an alarm connected to said sensor and said fluid  
93 detector and configured to output an alarm signal  
94 responsively to signals therefrom.

95 44. A device as in claim 43, wherein said alarm  
96 is adapted to output said alarm signal when either said  
97 sensor or said fluid detector indicates a leak.

98 45. A device as in claim 43, wherein said sensor  
99 is located to detect infiltration into a first part of said

100 fluid circuit and said fluid detector is located to detect  
101 fluid from a second part of said fluid circuit, said first  
102 and second parts having separate respective portions.

103 46. A device as in claim 43, further comprising  
104 a mechanism adapted to generate a negative pressure in said  
105 fluid circuit to cause air to infiltrate into a breach in  
106 said fluid circuit.

107 47. A device as in claim 46, wherein said  
108 mechanism is adapted to reverse a direction of flow of  
109 fluid in said fluid circuit.

110 48. A device as in claim 43, wherein said fluid  
111 circuit is a blood circuit.

112 49. A device as in claim 43, wherein said fluid  
113 processing machine is an extracorporeal blood processing  
114 machine.

115 50. A device for detecting a leak from a blood  
116 circuit of an extracorporeal blood treatment machine,  
117 comprising the steps of:

118 respective detectors located to detect leaks of  
119 blood from respective portions of a blood circuit;

120 at least two of said respective detectors  
121 including sensors configured to detect different physical  
122 effects correlated with one or more blood leaks;

123               said respective portions including parts that are  
124 non-overlapping.

125               51. A device as in claim 50, further comprising  
126 an output device connected to receive signals from said  
127 respective detectors and to output a signal responsively  
128 thereto.

129               52. A device as in claim 51, further comprising  
130 at least one of a fluid line clamp, a pump, and an actuator  
131 of a flow controller, connected to be controlled by said  
132 output device responsively to said signal.

133               53. A device as in claim 51, further comprising  
134 an alarm connected to be triggered by said signal.

135               54. A device as in claim 50, wherein said  
136 different physical effects include the infiltration of air  
137 into a blood circuit and the presence of blood outside said  
138 blood circuit.

139               55. A device as in claim 54, further comprising  
140 an alarm connected to receive signals from said respective  
141 detectors and to output a signal responsively thereto.

142               56. A device as in claim 54, further comprising  
143 an output device connected to receive signals from said  
144 respective detectors and to output a signal responsively  
145 thereto and at least one of a fluid line clamp, a pump, and

146 an actuator of a flow controller, connected to be  
147 controlled by said output device responsively to said  
148 signal.

149           57. A device as in claim 54, further comprising  
150 an output device connected to receive signals from said  
151 respective detectors and to output a signal responsively  
152 thereto and an alarm connected to generate an output  
153 responsively to said signal.

154           58. A device as in claim 57, wherein said output  
155 device and detectors are configured such that said signal  
156 indicates a leak if either of either of said respective  
157 different physical effects indicates a leak.

158           59. A device as in claim 58, wherein said  
159 different physical effects include the infiltration of air  
160 into a blood circuit and the presence of blood outside said  
161 blood circuit.

162           60. A device as in claim 59, wherein at least  
163 one of said detectors includes an air sensor and a  
164 mechanism adapted to periodically generate a negative  
165 pressure in said blood circuit such that air infiltrates  
166 said blood circuit through any openings therein.

167           61. A device as in claim 60, wherein said  
168 mechanism includes a mechanism adapted to reverse flow.

169           62. A device as in claim 50, further comprising  
170 a reversing valve, said different physical effects include  
171 the infiltration of air into said blood circuit caused by  
172 periodically reversing a flow of blood in said blood  
173 circuit using said reversing valve.

174           63. A device as in claim 62, wherein said  
175 detectors include a fluid sensor located inside a housing  
176 of said extracorporeal blood treatment machine.

177           64. A device as in claim 63, further comprising  
178 a flow guide adapted to guide and concentrate a leaking  
179 flow of blood toward said fluid sensor.